

Averaged Correlation Amplitude and Radio Flux Density

The *averaged correlation amplitude* is an index to explain structural changes of compact sources on the sun as well as changes of the radio flux density. Figure on the next page is a correlation diagram of the *averaged correlation amplitude* and the 17-GHz flux density for bursts observed simultaneously by the radioheliograph and the 17-GHz radio polarimeter at Nobeyama. Vertical axis of this figure is peak values of *averaged correlation amplitude* in unit of a digital number with a range from 0 to 32760. Horizontal axis is peak values of 17-GHz flux density in sfu, where 1 sfu is $10^{-22} \text{ W}\cdot\text{m}^{-2}\cdot\text{Hz}^{-1}$. The flux density is evaluated as an excess value from a pre-burst level. A line drawn in the diagram is obtained by the least squares fitting of the data to a linear equation. In this figure, we can see a positive correlation between the *averaged correlation amplitude* and the 17-GHz flux density. Degree of the correlation is relatively low, but the diagram gives a rough scale-transform relation between the *averaged correlation amplitude* and the flux density.

The *averaged correlation amplitude* is obtained by averaging the amplitude of observed correlation coefficients over higher spatial frequencies. In the following lines, we explain a way to calculate this value for detailed understanding.

In the radioheliograph, complex correlation coefficients $\rho(s_{EW}, s_{NS})$ are observed between signals received by element antennas, where s_{EW} and s_{NS} is a spatial frequency given by projected east-west and north-south antenna spacings in wavelength unit to the plane perpendicular to the direction of the Sun. The complex correlation coefficients $\rho(s_{EW}, s_{NS})$ and the solar brightness distribution $I(\theta_{EW}, \theta_{NS})$ are related by Fourier transformation as follows,

$$\rho(s_{EW}, s_{NS}) = \iint_{\Omega} I(\theta_{EW}, \theta_{NS}) \cdot \exp\{-2\pi i(s_{EW} \cdot \theta_{EW} + s_{NS} \cdot \theta_{NS})\} d\theta_{EW} d\theta_{NS},$$

where θ_{EW} and θ_{NS} are east-west and north-south angles from center of the field of view. Ω is the field of view of the radioheliograph's element antennas. The *averaged correlation amplitude* $\bar{\rho}$ is defined by following equation,

$$\bar{\rho} = \frac{1}{N} \sum_{s_{EW}, s_{NS} \geq 100 \cdot s_0} |\rho(s_{EW}, s_{NS})|,$$

where s_0 is the fundamental spatial frequency defined as a projected minimum antenna spacing in wavelength unit. N is the number of data with the spatial frequency $\geq 100 \times s_0$.

The observation wavelength λ of the radioheliograph is 17.6 mm. The projected minimum antenna spacing is 1.528 m and the fundamental spatial frequency s_0 is about 86.8 at the zenith. The radioheliograph's field of view is given by inverse of the fundamental spatial frequency ($=1/s_0$), and is about $40'$, which is slightly larger than the apparent diameter of solar disk at 17 GHz. As higher spatial frequencies reflect smaller structures

of images, the spatial frequency of $100 \times s_0$ corresponds to the sources with the size of $24''$. The *averaged correlation amplitude* defined above reflects fine structures smaller than $24''$ at the zenith.